IMAGE RESIZE USING SINC FILTER IN LINEAR LUMEN SPACE

This application is a continuation of U.S. application Ser. No. 08/295,317 filed Aug. 24, 1994, now U.S. Pat. No. 5,572,608.

BACKGROUND OF THE INVENTION

This invention is related to commonly assigned patent applications. Reference track rectilinear correction Ser. No. 08/295,319 now U.S. Pat. No. 5,604,601 and Scanline Queuing For High Performance Image Correction Ser. No. 08/295,318 now U.S. Pat. No. 5,608,538 both filed Aug. 24, 1994.

BACKGROUND OF THE INVENTION

This invention relates generally to processing digitally stored images. More specifically, it relates to processing image data retrieved from a low precision image scanner to a normalized high quality digital image.

In photographic arts, as computer technology became widely available, it became possible to electronically scan the film image to a stored digitized electronic image in a computer system. Once the images are digitized, they may be archived, edited, enhanced or otherwise processed digitally.

High resolution scanners use an array of sensors arranged in a line which is mechanically moved across an image. The eye can detect jitter of less than a quarter pixel requiring, with a two thousand element array on a 35 mm film, mechanical accuracy closer than five wavelengths of light. To achieve this accuracy, current state-of-the-art scanners rely upon high precision registration and handling of the substrate, e.g., film, on which the image is placed past the scanning optics. Quite naturally, the precision hardware is also quite expensive. Nonetheless, high quality image data is retrieved and digitized.

It is desirable to produce a low-cost scanner available for personal use in business, home, and school. One obvious way to make a personal scanner less expensive is to replace the expensive image handling hardware with less expensive low precision hardware. However, low precision hardware will result in scanned images with inconsistent vertical and horizontal spacing as the motor which is used to move the image substrate past the scanner, slows down, speeds up or possibly even reverses in direction. Other errors can be induced from the shifts of the substrate within the hardware. Thus, in a scanner of this type, it will be necessary to provide a number of modifications and corrections to reduce the raw data to a normalized form consistent with a high quality image.

The present invention provides a filter queuing scheme to allow the corrections and adjustments to be made on oversampled raw scan data to reduce it to a corrected and normalized form.

SUMMARY OF THE INVENTION

Therefore, it is an object of the invention to correct for geometric distortions in a scanned image.

It is another object of the invention to allow the use of relatively inexpensive substrate handling mechanisms for scanning images.

It is another object of the invention to compensate for jitter in the scanning and handling mechanisms.

These and other objects are accomplished by a scanner which converts an oversampled substrate image into a digital pixel array which may be at an arbitrary sampling frequency lower than the first sampling frequency. The scanner sensor converts the substrate image into an array of analog pixels at a first sampling frequency. Preferably, the first sampling frequency substantially oversamples the image from the actual frequency desired in the final digital image. The analog pixels are converted into a first array of digital pixels. The first digital pixel array is converted by a sinc filter in the linear lumen domain, i.e. the digital pixels are linearly representative of the brightness of light sensed by the sensor, to a second array of pixels at a second sampling frequency. The second sampling frequency should be much lower than the first sampling frequency to produce high quality images with substantially fewer pixels than required by the prior art.

This specification contains many details to implement a new type of scanner which is fundamentally different from current art. So the reader is not lost in the profusion of details, it will help to keep the following "nontechnical" explanation in mind.

If the reader were to bend this page, lay it sideways and view it from the side, the image reaching the eyes would be badly distorted. The human eyes would add many more distortions while imaging it from two angles through a "fisheye" lens on to a retina which is not flat. The retina loses all sense of rectilinearity as it "scans" in an hexagonal grid that varies in resolution across the field by orders of magnitude. In the brain, even sense of dimensionality is lost as the two-dimensional image is processed in three-dimensional space.

Despite these extreme distortions, the reader viewing the crumpled page can easily tell if one line is out of square by a fraction of a millimeter. One of Murphy's supposed laws is that the eye of the head draftsman is more accurate than the finest instrument. The eye itself is probably less accurate than the artist's instrument. It is the processing after the eye which imparts the accuracy. All other scanners try to perfect the mechanism, flatten the paper, view it squarely, reduce distortion in the lens and put the sensors on a perfect square. This scanner is fundamentally different. It seeks to build a "brain", i.e. processor, to perfect an irregular image after physical capture. The result will be a fundamentally new generation of scanners that are more flexible, more accurate and less expensive.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects, features and advantages will be more easily understood in connection with the attached drawings and following description.

FIG. **1** illustrates the common types of mechanically induced errors which can occur in scanned image using a linear array.

FIG. **2**A is a diagram of the scanner coupled to a computer system.

FIG. **2**B is a block diagram of the computer coupled to the scanner.

FIG. **3** is a flow diagram of the overall process for correcting the scanned image.

FIG. **4** depicts the grid appearance at various stages of processing the scanned image.

FIG. **5**A depicts the triangular weighting of the lengthwise prescale process.

FIG. **5**B is a flow diagram of the lengthwise prescale process.

FIGS. **6**A and **6**B are diagrams of the translation of CCD array resolution pixels to the chosen resolution pixels in the crosswise scale process.